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NEW LIGHTS ON PROTOPLASM IN PLANTS.

(1) *Einleitung in die experimentelle Morphologie der Pflanzen.* By Dr. K. Goebel. Pp. viii+260. (Leipzig and Berlin: B. G. Teubner, 1908.) Price 8 marks.

(2) *Parthenogenesis und Apogamie im Pflanzenreiche.* By Dr. Hans Winkler. Pp. 166. (Jena: Gustav Fischer, 1908.) Price 4.50 marks.

(1) THE study of botany has passed through many different phases, but it has tended more or less steadily towards the fuller recognition of plants as living beings, to be studied in the whole cycle from their beginnings through their maturity to their decay, including their provision for the continuance of the race despite the death of the individual. For a time the motive for the study of plants was naturally the desire to find out the uses to which they could be put, and the keenest students were usually the physicians in their search for useful drugs. After the awakening of interest in such study for its own sake, it passed necessarily through a period of description of forms previously unknown, followed by efforts to bring order into the knowledge already accumulated, and to discover some system by which the various forms could be accurately identified.

The invention of the microscope and of the methods suitable for its employment as an instrument of research opened up new fields to the student of living things, but the living substance was not recognised as the builder of the framework of cell-walls and vessels until near the middle of last century. The recognition of protoplasm as the "physical basis of life" necessarily directed attention to the importance of gaining a knowledge of its properties, of its relations to its environment, and of its response to stimuli. Improvements in the microscope and in the technique of research, while helping to solve some problems, have opened up new lines of inquiry, and this has been peculiarly the case in recent years. A considerable new literature has grown up dealing with the questions that arise, and it is very desirable to have the lines of inquiry and the results attained presented in a clear and effective form, whether these cover the whole field or relate to only a part of it. The two works named above will be found most useful guides, the first to the knowledge gained by experimental researches into alterations in structure induced by action of external stimuli, or environment, and into regeneration when parts are injured or removed, and the second to the production of new individuals by the processes known as apogamy and parthenogenesis, and the relation of these processes to the normal production of the embryo from the fertilised ovum.

Prof. Goebel speaks with the authority of an adept on all questions of morphology; and in this new book (based on a course of lectures delivered in the winter of 1906, and issued as the first volume of a series of handbooks on the methods useful in the study of the natural sciences and of technology) there is presented a most useful guide towards a clear view of what has been accomplished, along with indications of promising subjects of investigation. The division into lectures has not been adhered to, the clearness of exposition alone suggesting the work of a skilled teacher; and, where desirable, the matter has been treated with greater fulness than would have been suitable in the original form. Numerous footnotes refer the student to all important sources of information.

Vascular plants supply by far the greater part of the material dealt with, mosses and thallophytes being referred to now and again by way of comparison. The necessity of studying the plant throughout its development as a condition of understanding its true nature and affinities is illustrated by examples that show great diversity between the corresponding parts of the young and of the adult, and the differences are traced to causes the action of which can be tested by experiment. The normal course of development is analysed into periods, each with a distinctive character, these being successively *morphological,* during which the members appear and cells are rapidly multiplied, and *physiologico-biological,* when the members attain their full size and maturity, and fulfil their part in the plant's well-being. Experiments prove that the action of environment depends largely on the period during which it has acted, and that the characters of the earlier period may be retained in the normally later stage, or may be reproduced in that stage by the influence of an environment appropriate to the earlier. The *Campanula rotundifolia* ("harebell" of England, "blue-bell" of Scotland) is found to be very well suited for these instructive experiments, the forms of its leaves showing very quickly the influence of changes in environment, and also that similar results may follow apparently very different causes, such as diminished light, lessened supply of water, or increase of the salts in solution in the water. Prof. Goebel is led to the generalisation that these external influences act indirectly by their altering the amount and kind of the food formed by the plant, and required to permit of the normal course of development, the external forms being conditioned by the vital activities of the plants, and by the food-supply to each part of it. Thus also he accounts for the phenomena of regeneration where the injury is not very great, or replacement by new parts of a similar kind if the parts removed were too extensive or too specialised in their structure to be regenerated simply. The same generalisation is used to explain the different behaviour of primary and lateral axes and appendages, when uninjured, and when lateral parts are modified to replace primary members that have been destroyed.

The quality of the food is held to explain the nature of the parts formed. Thus stolons (as in Circæa) are attributed to the amount of organised food, relatively to the inorganic, or ash, supplied to the growing-point of the stolon being greater than that supplied to the leafy shoot. Potato tubers afford very favourable subjects for experiments; *e.g.* if tubers are kept at not more than 7° C., few roots or leafy shoots are formed, but new tubers develop readily, though, of course, remaining small. If the parent tubers are then cultivated at 25° C., leafy shoots are freely formed, the younger tubers of the new growth often being continued into leafy shoots at the tip.

The relations between leafy shoots and inflorescences are discussed as conditioned by the relative amounts of organised and mineral supplies to each; and the well-known effects on trees of root-pruning and overfeeding are brought under the general law. Certain plants (*e.g. Veronica Beccabunga*) show that their inflorescences may readily be caused to grow into leafy shoots. Space will not permit of more than a passing reference to the very interesting discussion of the changes that can be induced in the colours of certain flowers and the structure of others by alterations of environment and food and of the conditions under which cleistogamous flowers are normally produced. The production of buds in abnormal situations, either as a usual occurrence, as on the leaves of *Cardamine pratensis* in autumn, or following the partial or entire separation of the part from the plant, so largely utilised in the multiplication of begonias, hyacinths, and certain other plants, is treated at considerable length, and is summed up as closely akin to regeneration, both being especially active at the growing-points of axes or leaves; but adult tissue in certain areas may revert to the embryonic state, these areas being along the veins; and the impulse to development, apart from external stimuli, is conditioned by the presence of the necessary constituents of the food, brought about in leaves, when the petiole is cut or broken, by the retention of the leaf's products within itself. The book, though not large, does not lend itself to a brief review, as it is conspicuously free from irrelevant or useless matter. The student will find in it much information of high value, and much to suggest new aspects of the life of plants and of how experimental methods may be usefully employed in the search after the laws that govern them.

(2) Dr. Winkler's work on parthenogenesis and apogamy is one of the excellent monographs that have rendered "Progressus Rei Botanicæ" indispensable in every botanical library. It deals with one aspect of the activity of protoplasm, as manifested in reproduction of the species by methods very different in some respects from the normal, and the possibility of which was scarcely suspected until comparatively recent years. But though of recent development, this field of research has had much attention directed to it, and a copious though rather scattered literature has appeared, rendering this review of the whole field most timely and helpful both in itself and as a guide to the original papers. It is no mere compilation, but is an excellent contribution to a difficult subject. A brief sketch of the history of the discovery of the methods of reproduction in plants up to the recognition of true sexual reproduction as normal in them forms an introduction to the later history of the discoveries that in some plants the sexual method is not followed, that the embryos result from a vegetative growth of some other cell or cells than the ovum, and that the unfertilised ovum may develop as an embryo. These abnormally produced embryos have been studied in their origin and growth in numerous species (from widely different groups of plants) both as they occur naturally and as they result from external stimuli, such as injuries to the parts that produce them, various salts in solution, or differing concentration of food-solutions.

The terminology in use for these methods of reproduction has varied as employed by different investigators, and the terms are reviewed and defined clearly. The methods of production of new individuals are recognised as of three types, viz. *amphimixis,* the embryo resulting from the union of two clearly distinct cells, the ovum and sperm, or their equivalents, this being true sexual reproduction; *pseudomixis,* the embryo being developed, directly or indirectly, from a union of two cells not the equivalents of the ovum and sperm, as has been observed to occur in certain ferns (in which a cell of a prothallus after entrance into it of the nucleus of a neighbouring cell, and union of the nuclei, produces a new fern plant), and probably also in the reproduction of various fungi (while similar nuclear fusions, unconnected with reproduction, have been found to occur as an effect of chemical agents, *e.g.* of chloral on roots of Vicia); and *apomixis,* where the production of the new individual has not been preceded by fusion of nuclei, either sexual or asexual, and is evidently asexual.

The term apogamy was first used by de Bary (in 1878) to signify the replacement of sexual reproduction by any other method, *i.e.* as almost equivalent to *apomixis*; but it has been used by others with meanings a good deal different from this. Dr. Winkler therefore defines his own use of the terms, thus:—Apogamy is the apomictic formation of sporophytes from vegetative cells of the gametophyte; Parthenogenesis is the apomictic formation of a sporophyte from an ovum. Each is distinguished into two types by the number of chromosomes in the nuclei of the cells giving origin to the new plants, viz. somatic with diploid, and generative with haploid nuclei. With these restrictions, the conditions that lead to, or favour, the occurrence of one or other of these modes of reproduction, their relations to the more usual sexual and asexual types, and their biological significance are treated in a very full and thorough manner, supplemented by a bibliography including 239 titles.

Before describing more fully the ascertained cases of apogamy and parthenogenesis, a careful analysis is made of many recorded cases in which the conditions are uncertain, or too insufficiently observed to allow of determining to which type they belong. Among these are examlpes of algæ such as Protosiphon, shown by Klebs to be capable of facultative parthenogenesis, or of union of gametes, under definite changes of food-solution or of temperature, but in which the number of the chromosomes in the plant developed in each case has not been ascertained. Other cases insufficiently determined in this respect are met with among fungi, as in *Mucor racemosus*, possibly among Bryophyta, and in one or two gymnosperms. A considerable number of angiosperms have been recorded as producing embryos otherwise than from the fertilised ova, but in a large proportion of cases doubt exists as to the true origin of such embryos and as to the behaviour of their chromosomes, while other reported cases are much in need of re-investigation of the alleged facts.

Having set aside all doubtful cases, there remain several in which the whole course of formation of the new individual has been followed out and made known in its details. Apogamy was first studied in the outgrowth of a fern plant directly from the prothallus. Occurring in certain varieties of different species, the details of the process have been found to differ widely; *e.g.* pseudomixis prevails in *Lastrea pseudomas*, var. *polydactyla*; somatic apogamy in *Athyrium Filix-foemina*, var. *clarissima*, and generative apogamy in *Nephrodium molle*. Somatic apogamy is not common among phanerogams, but has been shown to occur in *Alchemilla sericata*, one of the helper-cells giving rise to an embryo along with the parthenogenetic ovum, while in *Balanophora elongata* somatic apogamy leads to an embryo being formed from a cell of endosperm.

Generative apogamy is illustrated in the development of embryos from antipodal cells in *Allium odorum*, but it also is in want of further study among phanerogams.

Generative parthenogenesis has been observed among a few algæ (*Spirogyra mirabilis, Cosmarium Botrytis*, &c.), chiefly under artificial stimuli, and possibly also among fungi, but not among other plants. Somatic parthenogenesis, on the other hand, has not been proved to exist among the purely cellular plants, while it has been met with in true ferns (*e.g. Ath. Filix-foemina*, var. *clarissima*) and *Marsilia Drummondii*, and in several dicotyledons, especially among Compositæ (*Antennaria alpina* and other species, *Taraxacum*, sps., *Hieracium*, sps.), in *Alchemilla*, sps., in *Thalictrum*, sps., &c. In all these flowering plants the pollen of the parthenogenetic species is ill-developed or useless. Parthenocarpy or the formation of apparently fully developed fruits from unpollinated or unfertilised carpels is a well-known fact, especially among cultivated plants, and has led not infrequently to the assumption of parthenogenesis, but in these cases the fruits are often sterile, as in bananas and other seedless fruits.

The latter part of the monograph is devoted to such speculative questions as whether the parthenogenetic ovum is a somatic or a truly generative cell; whether apogamy and parthenogenesis lead to the suppression of alternation of generations in plants in which it normally exists; the origin and mutual relations in the cycle of the haploid and diploid types of cells; and the possible advantages of their intercalation in the cycle; the causes and explanations of parthenogenesis and apogamy, and the information on these derived from experiments. The discussion of these topics is suggestive and full of interest, but the reader must be referred to the work itself, as it is not possible to summarise fairly the views stated. It may be said that there is still much to be done before the way is clear.

The biological value to plants of parthenogenesis and apogamy is evidently, like that of increase by tubers, stolons, bulbs, and other purely vegetative methods, the multiplication of the species by seeds, or other readily dispersed bodies, in which the embryo is produced without dependence on access of male cells, whether sperms or pollen-nuclei, thus securing the reproduction even from isolated female plants. The disappearance of the pollen-bearing plants in habitually parthenogenetic species is regarded as a consequence, instead of as the cause, of parthenogenesis. It has been observed that among the genera that show the most marked tendency to this condition are several (Hieracium, Alchemilla, &c.) peculiarly rich in closely allied forms, regarded by some as species, by others as varieties; but, on the other hand, other polymorphic genera (Rubus, &c.) show sexual reproduction of the normal kind. There are very evidently many problems in these and other fields relating to protoplasm still waiting to reward research.

ADMISSIONS OF AN ANTI-VIVISECTIONIST.

The Vivisection Controversy. Essays and Criticisms. By Dr. Albert Leffingwell. Pp. vi+251. (London: The London and Provincial Anti-vivisection Society, 1908.) Price 6*s*.

DR. ALBERT LEFFINGWELL is an American doctor who, as we gather from his title-page, has written on the "Morality of London" and on "Rambles in Japan without a Guide"; and who, "having witnessed experiments on animals by some of the most distinguished European physiologists, such as Claude Bernard, Milne Edwards and Brown Sequard, began to contribute to the vivisection controversy twenty-eight years ago." He is contributing still, and he is no exception to the rule that when an anti-vivisectionist arrives at the controversial stage the impression he makes on a logical mind is not a favourable one. That is because anti-vivisectionists, by addressing themselves continually and solely to audiences of convinced sentimentalists, acquire the habits of rhetoric and over-statement, and become incapable of stating any fact regarding the use of animals in experiment except in a controversial relation. Thus Dr. Leffingwell will not allow to experiments on animals any of the credit for antiseptic or aseptic methods in surgery; he denies, as most anti-vivisectionists do, any reduction in diphtheria mortality, or virulence, by the use of antitoxin; he minimises, so far as he can, the use of antitetanus and antivenous serums. He says nothing about bacteriological research in plague, typhoid, Malta-fever, or malaria; but that is partly because the bulk of his essays were published before those researches were undertaken. It is also because the essays are filled so largely with appeals to the emotions, with quotations from Mrs. Barrett Browning's "Cry of the Children," and with long references to the iniquities of the slave trade, that there is very little room even